# PREDICTING ADRIATIC METEOTSUNAMIS USING SATELLITE - BASED NOWCAST

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## ABSTRACT

The analysis of the four strongest Adriatic meteotsunamis in the past 30 years pointed out that in each case a convective system was present in the area. Additionally, the propagation speed of the atmospheric disturbances seems to have been around 22 m $s^{-1}$ in all discussed cases. That led to the assumption that a convective system is responsible for causing the disturbance leading to meteotsunami formation. Since the convective cells can be recognized and their movement can be followed using the nowcasting tools based on satellite data, a method for predicting the occurrence of meteotsunamis in the Adriatic is proposed.

## INTRODUCTION

Meteotsunamis are large amplitude sea waves generated by a propagating atmospheric disturbance. A detailed description of their origin, formation and propagation can be found in Monserrat et al. (2006). These types of waves are common all over the world and are known by their local names such as abiki in Japan, marrubio in Italy, milghuba on Malta and rissaga in the Balearic Islands. These waves are also documented in the Adriatic Sea (*Vilibić et al*., 2004, *Vilibić and Šepić*, 2009), where they cause problems since the coastal infrastructure is not adapted to such a large sea level oscillation.

The conditions required for the occurrence of a meteotsunami can be summarized as follows (Vilibić et al., 2004, Monserrat et al., 2006):

1. Presence of a strong small-scale atmospheric disturbance that propagates over the sea.
2. The speed of the atmospheric disturbance equals the phase speed of open sea waves.
3. A harbour or a bay with eigenfrequency equal to the frequency of the incoming open sea waves.

## OVERVIEW OF THE STRONGEST ADRIATIC METEOTSUNAMI CASES

There must have been many meteotsunami events in the Adriatic in the past but they were not documented because they either did not hit a populated place or did not cause too much damage. Therefore, in the past 30 years only four cases were sufficiently documented. First known case that hit the Vela Luka bay on the island of Korčula on 21 June 1978, described in detail by Hodžić, 1988, could not be documented by the satellite data. However, the results of mesoscale modelling showed that convective precipitation was present above the area.

Satellite images for 27 June 2003 show that in the case of Stari grad and Mali Ston meteotsunami, analyzed by Belušić et al., 2007, a large convective system was present above the area, moving along the Adriatic coast towards the south-east (Fig. 1).

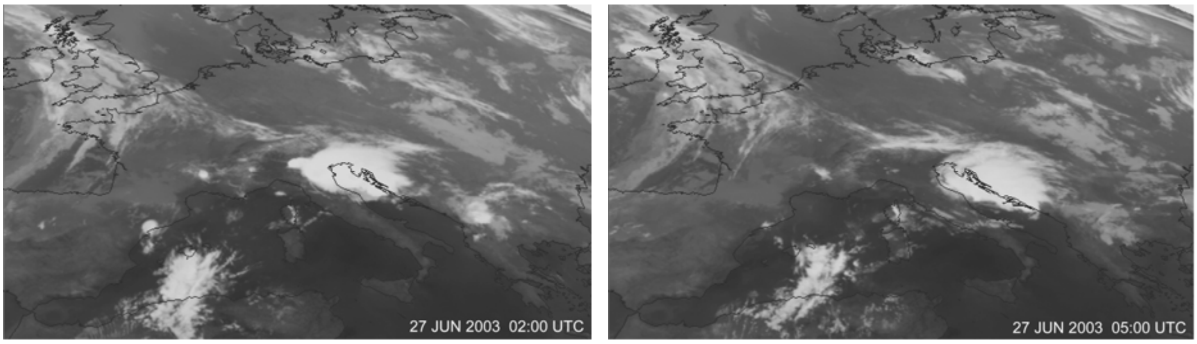


***Figure 1:*** Meteosat 7 IR images for 27 June 2003 at 02:00 UTC and 05:00 UTC

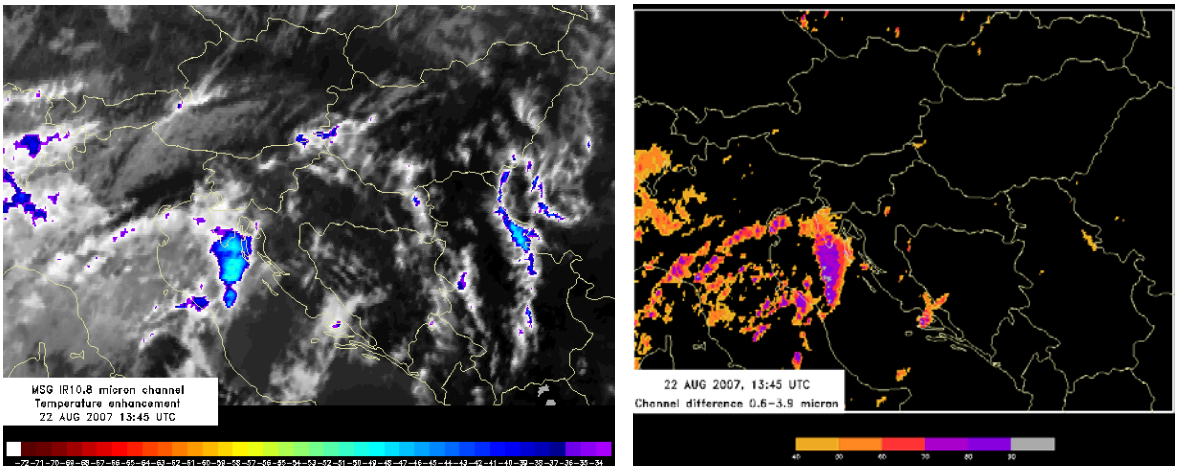


***Figure 2:*** Meteosat-9 images for 22 August 2007 at 13:45 UTC: color-enhanced IR10.8 μm (left) and the difference of reflectance in 0.6 - 3.9 μm channel (right).

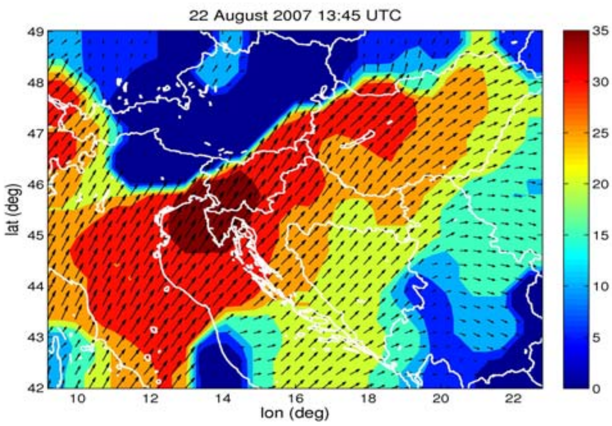


***Figure 3:*** Cloud motion vectors for 22 August 2007 at 13:45 UTC based on Meteosat-9 IR10.8 μm channel data. Colour shades depict the speed of the movement.

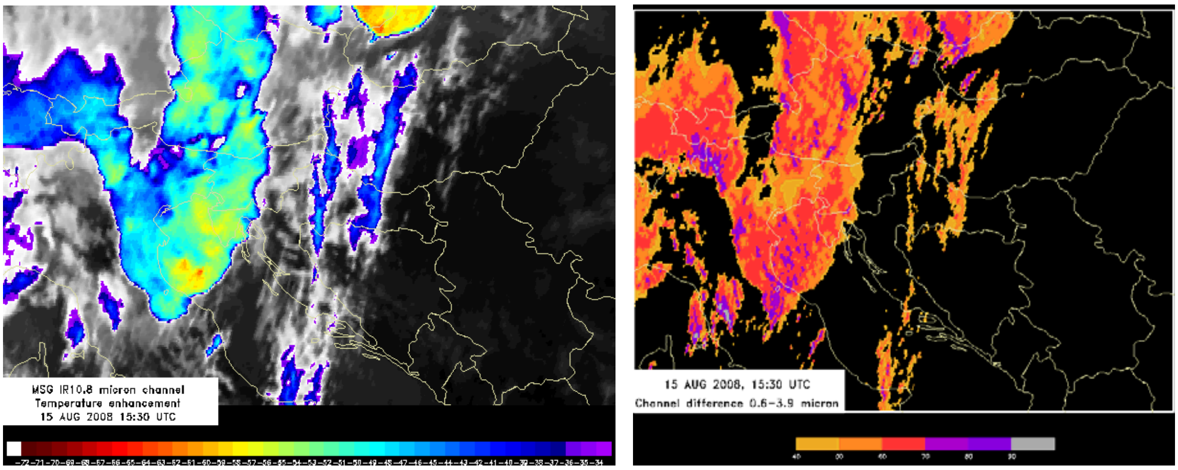


***Figure 4:*** Meteosat-9 images for 15 August 2008 at 15:30 UTC: colour-enhanced IR10.8 μm image (left) and the difference of reflectance in 0.6 - 3.9 μm channel (right).

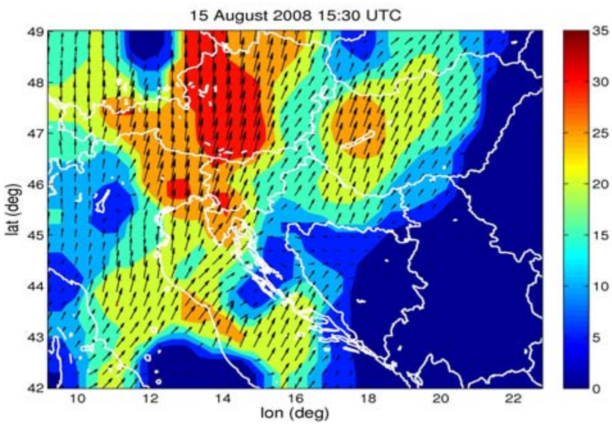


***Figure 5:*** Cloud motion vectors for 15 August 2008 at 15:30 UTC based on Meteosat-9 IR10.8 μm channel data. Colour shades depict the speed of the movement.

For the two most recent cases, the Ist case on 22 August 2007 (Šepić et al., 2009) and the Mali Lošinj case on 15 August 2008, a detailed analysis of the satellite data was performed by Belušić and Strelec Mahović, 2009. Convective cells were detected based on IR10.8 μm images (Setvak et al., 2006), as well as the difference between reflectance values in 0.6 and 3.9 μm channel (Strelec Mahović and Zeiner, 2009), whereas the cloud motion vectors were calculated by the cross-correlation technique similar to that described in Kidder and Vonder Haar, 1995.

## CONCLUSION

In all four Adriatic meteotsunami cases a travelling convective system served as the generator of a surface pressure perturbation. In order to predict a meteotsunami it would be important to know the exact location as well as the speed and direction of the propagation of the convective system. This is determined by calculating cloud motion vectors from successive satellite images. The velocity derived in this way is associated to the cloud-top movement and not to the speed of the surface perturbation responsible for the meteotsunami generation. However, the two velocities, although not the same, are presumably strongly related. If the speed of a recognized convective system is close to the phase speed of the open sea waves (for Adriatic a constant value of 22 m $s^{-1}$ is taken), a meteotsunami warning might be issued to the regions that are located downstream relative to the direction of propagation of the system.

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